(12) UK Patent Application (19) GB (11) 2 253 282 (13) A

(43) Date of A publication 02.09.1992

(21) Application No 9104081.6

(22) Date of filing 27.02.1991

(71) Applicant
British Aerospace Public Limited Company

(Incorporated in the United Kingdom)

11 The Strand, London, WC2N 5JT, United Kingdom

(72) Inventors
Peter Charles Morgan
Stewart Wynn Williams

(74) Agent and/or Address for Service
British Aerospace Public Limited Company
PO Box 87, Company Headquarters, Royal Aerospace Establishment, Farnborough, Hants, GU14 6YU, United Kingdom

(51) INT CL[5]
B23K 26/00

(52) UK CL (Edition K)
G3N NGE1 N284 N404
B3R RAC R138
B3V VLD
U1S S1645 S1673 S1909

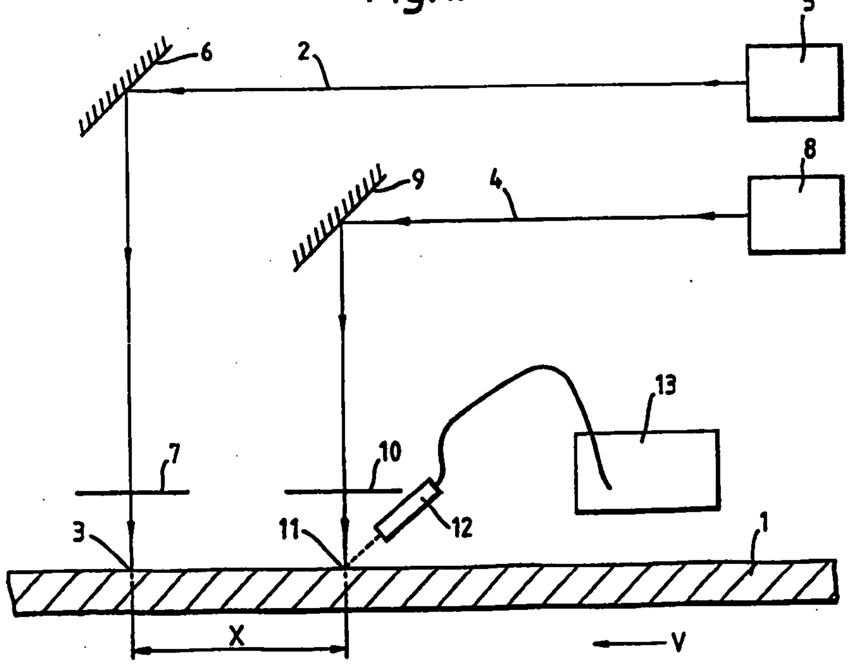
(56) Documents cited
GB 2039462 A GB 1591314 A EP 0278643 A
JP 560041089 A

(58) Field of search
UK CL (Edition K) B3R RAC, B3V VLD, G3N NGE1 NGE1A NGE1B
INT CL[5] B23K 26/00
Online database: WPI.

(54) Method and apparatus for controllably laser processing a surface

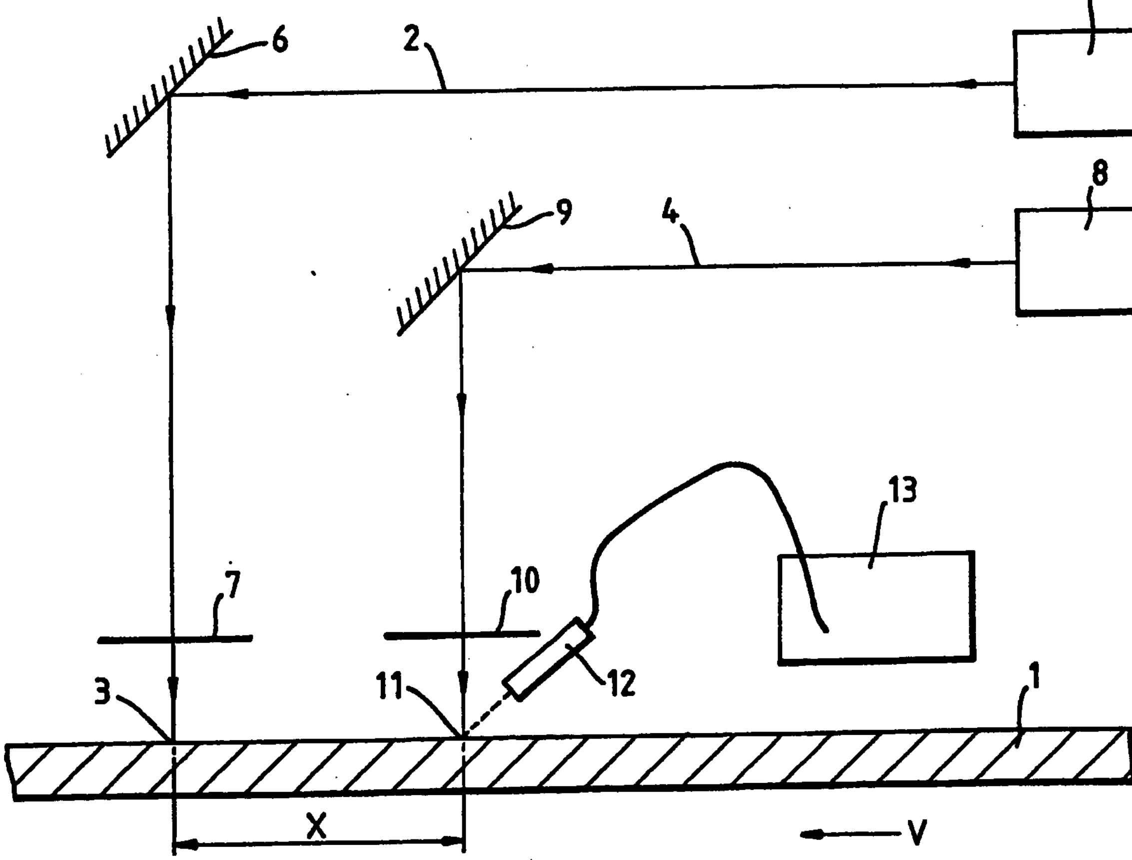
(57) Laser treatment of an e.g. metallic surface (1) such as welding or cutting, is carried out by impinging a process beam (2) of laser radiation on the surface (1). A monitoring laser beam (4) of the same wavelength but lower intensity is impinged on the surface prior to the process beam impingement. The change in temperature of the surface (1) resulting from the monitoring beam impingement is measured by means (12) to determine the effective absorption coefficient dependent upon the condition, composition and/or microstructure of the surface (1). At least one operating characteristic of the process beam (2) is varied in dependence upon the measured effective absorption coefficient in order to deliver a constant heat input to the surface along the line of the cut or weld. The beam intensity or the speed of traverse may be varied.

Fig.1.



GB 2 253 282 A

Fig. 1.



METHOD AND APPARATUS FOR CONTROLLABLY LASER PROCESSING A SURFACE

This invention relates to a method and apparatus for controllably processing laser processing a surface by impingement of a process beam of laser radiation on the surface.

Laser processing of a surface to manufacture a component can give rise to problems in the quality of the finished component. For example in laser cutting the quality of the edge produced by the cutting can be a problem and in laser welding the quality of weld produced can also be a problem. The quality of the cut edge and/or weld is significantly affected by the amount of heat put into the surface by the process laser.

There is thus a need for a generally improved method and apparatus for laser processing a surface which minimises the quality problems produced by excessive heat.

According to one aspect of the present invention there is provided a method of controllably laser processing a surface by impingement of a process beam of laser radiation on the surface, including the steps of measuring the effective absorption coefficient of the surface, which effective absorption coefficient is dependent upon the condition, composition and/or microstructure of the surface, and varying at least one operating characteristic of the process beam in dependence upon the effective absorption coefficient measured, to compensate for variation in condition, composition and/or microstructure of the surface and thereby control the laser processing.

Preferably the effective absorption coefficient is measured by impinging at a first point on the surface, prior to said process beam impingement, a monitoring beam of laser radiation of substantially the same wavelength as the process beam and of known intensity, and measuring the change in temperature of the surface at the first point resulting from the monitoring beam impingement.

Advantageously subsequent to monitoring beam impingement at the first point, relative movement is effected between the beams and surface such that the first point at which the monitoring beam has been impinged becomes the point at which process beam impingement is effected.

Conveniently relative movement between the beams and surface is effected by movement of the surface relative to the beams.

Preferably the process beam is a cutting or welding beam and the varied operating characteristic is the power input to the process beam or the processing speed.

Advantageously the process beam is a beam of high power laser radiation preferably produced by an infra-red laser.

Conveniently the monitoring beam is a beam of low power laser radiation.

Preferably the surface to be processed is metallic and/or non-metallic.

According to a further aspect of the present invention there is provided apparatus for controllably laser processing a surface, means for measuring the effective absorption coefficient

of the surface, which coefficient is dependent upon the condition, composition and/or microstructure of the surface, and means for varying at least one operating characteristic of the process beam in dependence upon the varying effective absorption coefficient to compensate for variation in condition, composition and/or microstructure of the surface.

Conveniently the process beam impinging means and the monitoring means impinging means are each a lens and mirror combination, a focusing mirror assembly or a fibre optic assembly.

Advantageously the process beam source is a high power laser, the process beam impingement means and the monitoring beam impingement means are spaced apart by an amount such that the monitoring beam impinges at a first point, and following relative movement between the surface and process beam, the process beam impinges on the first point, the monitoring beam source is a low power source, the temperature change measuring means is a radiation detector coupled to a controller/processor to process an output signal from the detector to provide the effective absorption value, and wherein the main beam operating characteristic varying means is a device for continuously controlling process beam laser power or velocity of relative movement between the process beam and surface.

Preferably the process and monitoring laser beam sources are infra-red lasers, with the monitoring beam laser having substantially the same wavelength as and similar beam properties

to the process beam laser, and with the detector being an infra-red radiation detector.

For a better understanding of the present invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying single figure drawing, in which:

Figure 1 is a diagrammatic view of a surface to be processed and apparatus according to a first embodiment of the invention for carrying out the method of the invention.

The method and apparatus of the present invention is useful for laser processing any suitable material such as a metallic material, non metallic material, such as a polymer, ceramic, cermet and/or composite such as a fibre composite or a metal matrix composite. The processing may involve cutting, welding or surface or in depth treatment.

The cut edge quality or weld quality of a surface 1, preferably made of metal is significantly affected by the amount of heat put into the surface by a process beam 2 of laser radiation impinging on the surface 1 and the amount of heat generated in the surface 1 by the laser beam 2 is significantly affected by the effective absorption of the heat by the material of the surface 1. The effective absorption value varies with the condition, composition and/or microstructure of the metallic surface 1 (for example microrelief, oxide coverage, inclusions). The effective absorption value may therefore vary spatially along the surface 1 and may also vary with time. This variation is particularly likely in the case of metallic surfaces which have

been pretreated with an ultra-violet laser to enhance their effective absorption.

The method of the present invention for laser processing a surface 1 by impingement of a process beam 2 of laser radiation at a point 3 on the surface 1 includes the steps of impinging at a first point 11, prior to process main beam impingement, a monitoring beam 4 of laser radiation of known intensity and of substantially the same wavelength as the process beam 2, measuring the effective absorption value, such as by measuring the change in temperature of the surface 1 at the first point 11 resulting from monitoring beam impingement, to provide an effective absorption value dependent upon the condition, composition and/or microstructure of the metallic surface 1 at the first point 11, and varying at least one operating characteristic of the process beam 2 in dependence upon the varying effective absorption value to compensate for variation in condition, composition and/or microstructure of the surface 1 at the first point 11.

Subsequent to monitoring beam impingement at the first point 11, relative movement is effected between the beams 2, 4 and surface 1, such that the first point 11 at which the monitoring beam 4 has been impinged becomes the point 3 at which process beam impingement is effected. Such relative movement between the beams 2, 4 and surface 1 conveniently is effected by movement of the surface 1 relative to the beams 2, 4.

In an embodiment of the invention as illustrated in Figure 1 of the accompanying drawings, an apparatus is provided which is particularly suitable for cutting or welding. To this end the process beam 2 is a cutting or welding beam of high power laser radiation, produced by an infra-red laser source 5. The apparatus includes means for impinging the process beam 2 at the point 3, which means as illustrated comprises a lens and mirror combination made up of a mirror 6 and a lens 7. The monitoring beam 4 is provided by a low power laser radiation source 8 producing radiation of known intensity which has preferably the same wavelength as and similar beam properties to the radiation produced by the high power laser source 5. Preferably the beam 4 has substantially constant intensity.

Means are provided for impinging the monitoring beam 4 at the first point 11 prior to main beam impingement. Again the monitoring beam impinging means preferably comprises a mirror 9 and focusing lens 10. Alternatively the lens and mirror combinations 6 and 7 and 9 and 10 could be replaced by individual focusing mirror assemblies or fibre optic assemblies.

The process beam 2 is brought to the surface 1, at a power density sufficient to carry out the required treatment of welding or cutting, via the mirror 6 and lens 7. The beam 2 theoretically strikes the surface 1 at the point 3 which is spaced from the first impingement point 11 of the monitoring beam 4 by an offset amount X. Preferably this distance X is variable. The spacing apart of the lens and mirror combination 6, 7 and 9, 10 is such that the monitoring beam 4 impingement first point

11 is the same as the process beam impingement point 3 following relative movement between the surface 1 and beam 2, so that, in effect, the beam 2 and beam 4 can be said to impinge at the first point 11. The mirror 9 and lens 10 are the same as the mirror 6 and lens 7 to ensure that the area probed by the monitoring beam 4 is the same as that treated by the process beam 2. The monitoring beam laser source 8 may be chopped or pulsed to avoid problems of preheating the sample area from an adjacent sample area. The monitoring beam 4 induces a small temperature rise, for example 100°C at its impingement point 11 and this will depend upon the effective absorption for the laser beam at the laser wavelength at that particular point.

The apparatus includes means for measuring the change in temperature at the surface 1 and includes a radiation detector 12 which measures the amount of infra-red radiation emitted. The wavelength of the infra-red light that is monitored or detected by the detector 12 is different to that of the monitoring beam 4 to avoid noise effects. The means also includes a controller/processor 13 which receives an output signal from the detector 12 and processes it to provide the required effective absorption value at the impingement point. Means are also provided for varying at least one operating characteristic of the process beam 2 in dependence upon the varying effective absorption value to compensate for variation in condition, composition and/or microstructure of the metallic surface at the first point 11. This means (not illustrated) receives the effective absorption value from the controller/processor 13 and

either controls the power input to the laser beam 2 or the relative velocity V between the process beam 2 and surface 1. When the surface 1 has moved a distance X relative to the beam 2 the monitored impingement point 11 of the monitoring beam 4 is coincident with the impingement point 3 of the process beam 2. In other words the impingement point 11 of the monitoring beam 4 previously probed moves along a distance X by movement of the surface 1 towards the process beam 2 to become the first impingement point 3 for the process beam 2. At this point the laser power of the beam 2 or the velocity V of the surface 1 of the surface 1 is adjusted by the controller/processor 13 to take account of the effective absorption value previously established so that the heat input remains constant. This is monitoring of the effective absorption coefficient prior to treatment by the laser beam 2. As the effective absorption coefficient is found to vary along the surface 1 the power input to the laser beam 2 or the velocity V of relative movement between the process beam 2 and surface 1 is varied to compensate for this. This ensures that the heat input to the surface 1 remains constant ensuring minimum heat effective zone effects, increased treatment speed and high efficiency high quality uniform treatment.

CLAIMS

1. A method of controllably laser processing a surface by impingement of a process beam of laser radiation on the surface, including the steps of measuring the effective absorption coefficient of the surface, which effective absorption coefficient is dependent upon the condition, composition and/or microstructure of the surface, and varying at least one operating characteristic of the process beam in dependence upon the effective absorption coefficient measured, to compensate to variation in condition, composition and/or microstructure of the surface and thereby control the laser processing.

2. A method according to claim 1, in which the effective absorption coefficient is measured by impinging at a first point on the surface, prior to said process beam impingement, a monitoring beam of laser radiation of substantially the same wavelength as the process beam and of known intensity, and measuring the change in temperature of the surface at the first point resulting from the monitoring beam impingement.

3. A method according to claim 2, in which subsequent to monitoring beam impingement at the first point, relative movement is effected between the beams and surface such that the first point at which the monitoring beam has been impinged becomes the point at which process beam impingement is effected.

4. A method according to claim 3, in which relative movement between the beams and surface is effected by movement of the surface relative to the beams.

5. A method according to claim 4, in which the process beam is a cutting or welding beam and in which the varied operating characteristic is the power input to the process beam or the processing speed.

6. A method according to any one of claims 1 to 5 in which the process beam is a beam of high power laser radiation.

7. A method according to claim 6, in which the high power laser radiation is produced by an infra-red laser.

8. A method according to any one of claims 1 to 7, in which the monitoring beam is a beam of low power laser radiation.

9. A method according to any one of claims 1 to 8, in which the surface to be processed is metallic and/or non-metallic.

10. A method of controllably processing a laser surface by impingement of a process treatment beam of laser radiation on the surface, substantially as hereinbefore described with reference to Figure 1 of the accompany drawings.

11. Apparatus for controllably laser processing a surface, including a source of process beam of laser radiation, means for impinging the process beam on the surface, means for measuring the effective absorption coefficient of the surface, which coefficient is dependent upon the condition, composition and/or microstructure of the surface, and means for varying at least one operating characteristic of the process beam in dependence upon the varying effective absorption coefficient to compensate

for variation in condition, composition and/or microstructure of the surface.

12. Apparatus according to claim 11, wherein the process beam impinging means and the monitoring beam impinging means are each a lens and mirror combination, a focusing mirror assembly or a fibre optic assembly.

13. Apparatus according to claim 12, wherein the process beam source is a high power laser, the main beam impingement means and the monitoring beam impingement means are spaced apart by an amount such that the monitoring beam impinges at a first point, and following relative movement between the surface and process beam, the process beam impinges at the first point, the monitoring beam source is a low power source, the temperature change measuring means is a radiation detector coupled to a controller/processor to process an output signal from the detector to provide the effective absorption value, and wherein the main beam operating characteristic varying means is a device for continuously controlling process beam laser power or velocity of relative movement between the process beam and surface.

13. Apparatus according to claim 13, wherein the process and monitoring laser beam sources are infra-red lasers, with the monitoring beam laser having substantially the same wavelength as and similar beam properties to the process beam laser, and with the detector being an infra-red radiation detector.

14. Apparatus according to claim 13 or claim 14, including means for moving the surface relative to the process beam.

15. Apparatus for laser processing a surface, substantially as hereinbefore described and as illustrated in Figure 1 of the accompanying drawing.

Patents Act 1977
⁻xaminer's report to the Comptroller under Section 17 (The Search Report)

Application number
9104081.6

Relevant Technical fields

(i) UK Cl (Edition K) G3N NGE1, NGE1A, NGE1B

(ii) Int Cl (Edition 5) B23K 26/00

Search Examiner

P MARCHANT

Databases (see over)
(i) UK Patent Office

(ii)
.ONLINE DATABASE: WPI

Date of Search

30.5.91

Documents considered relevant following a search in respect of claims 1-13 and (the wrongl numbered) 14-16

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X,Y	GB 2039462 A (CEGB) see especially page 2 lines 48-93	1,11,6
Y	GB 1591314 (STEIGERWOLD) see especially page 2 line 13, page 2 lines 51-62 and 63-67, figure 2 and page 2 line 105	1,11,2, 3,5,6, 13
Y	EP 278643 A (DIRLEY) whole document	1,11
X,Y	JP 56041089 (SHIBAURA) see abstract	1,2,5,6, 11

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

Published 1992 at The Patent Office, Concept House, Cardiff Road, Newport, Gwent NP9 1RH. Further copies may be obtained from Sales Branch, Unit 6, Nine Mile Point, Cwmfelinfach, Cross Keys, Newport, NP1 7HZ. Printed by Multiplex techniques ltd, St Mary Cray, Kent.